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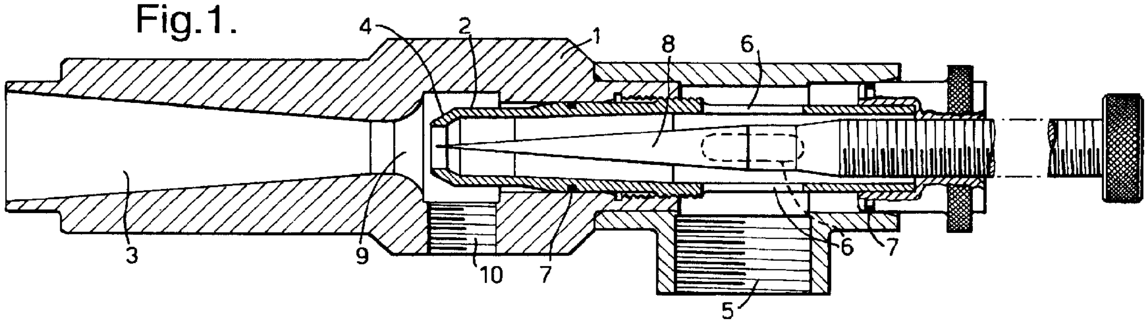
(54) Ejector

(57) An ejector for mixing and ejecting two or more fluids comprises a nozzle (2) having a generally conical outer surface (4); a first fluid inlet (5) through which a first fluid is supplied to the nozzle (2) under pressure; a throttle (8) for controlling the cross-sectional area of the outlet of the nozzle (2); an ejector throat (9) having a generally conical inner surface which surrounds and is downstream of the generally conical outer surface (4) of the nozzle (2); and, a second fluid inlet (10) through which a second fluid is supplied in communication with the ejector throat (9). The first fluid is jetted through the nozzle (2) into the ejector throat (9) and draws the second fluid into the ejector throat (9) from where the first and second fluids are ejected. With this arrangement, the flow rate of the jetted fluid through the nozzle can be controlled by varying the cross-sectional area of the opening of the nozzle (2) using the throttle (8) without reducing the velocity of the jet of the first fluid.

Fig.1.



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Description

The present invention relates to an ejector for mixing and ejecting two or more fluids. In many circumstances, it is desired to mix and eject fluids against a back pressure. One example of a system in which such an ejector is required is for the supply of regenerant chemicals for the regeneration of ion exchange resins in an ion exchange column.

One example of an ejector is disclosed in our earlier application, GB-A-2,207,952. The ejector disclosed in this application includes an ejector nozzle having a generally conical outer surface which is coaxially arranged with respect to an inlet to an ejector throat, the inlet having a generally conical inner surface which surrounds the nozzle. One of the fluids to be mixed is supplied, under pressure, to the nozzle. The fluid is jetted into the ejector throat at a high velocity. The other fluid is supplied to a chamber in communication with the ejector throat. The high velocity, jet of fluid through the nozzle causes a reduced pressure around the outside of the ejector throat which draws the other fluid into the throat. The fluids flow through the ejector throat, and enter a diffusion portion where the fluids are mixed and from which they are ejected.

The relative position of the nozzle and the inlet to the ejector throat are adjustable. By adjusting the spacing between the nozzle and the inlet, the quantity of the other fluid drawn into the throat by the jetted fluid is controllable.

With this system, it is not possible to control the flow rate and volume of the jetted fluid to be mixed with the fluid drawn into the ejector throat. If the pressure of the fluid supplied to the nozzle is reduced to reduce the flow rate of the jetted fluid, the velocity of the fluid will drop, and therefore there will be insufficient suction created in the ejector throat to draw the other fluid into the throat. This problem is accentuated where there is a large back pressure.

According to the present invention, an ejector comprises:

a nozzle having a generally conical outer surface;
a first fluid inlet through which a first fluid is supplied to the nozzle under pressure;
a throttle for controlling the cross-sectional area of the outlet of the nozzle;
an ejector throat having a generally conical inner surface which surrounds and is downstream of the generally conical outer surface of the nozzle; and,
a second fluid inlet through which a second fluid is supplied in communication with the ejector throat, in which the first fluid is jetted through the nozzle into the ejector throat and draws the second fluid into the ejector throat from where the first and second fluids are ejected.

With this arrangement, the flow rate of the jetted fluid through the nozzle can be controlled by varying the cross-sectional area of the opening of the nozzle using the throttle without reducing the velocity of the jet of the first fluid. Accordingly, the volume of the jetted fluid which is mixed and ejected with the second fluid is controllable, without reducing the velocity of the first fluid. By maintaining the high velocity jet, enough suction is generated so that the second fluid is drawn into the ejector throat.

Preferably the position of the nozzle relative to the ejector throat is controllable. This allows control of the flow rate of the second fluid which may depend on the spacing between the outer surface of the nozzle and the inner surface of the ejector throat. Alternatively the outer surface of the nozzle may form a seal with the second fluid inlet so that as the nozzle is moved it opens and closes the inlet. In this case the inlet is preferably shaped as a slot or as a triangular aperture to achieve the correct proportioning between the movement of the nozzle and the flow rate of the second fluid through the inlet. This give control of the volumes of both the first and second fluids.

The nozzle may be provided on a hollow nozzle body. In this case, the nozzle body may include apertures in its side wall through which fluid from the first fluid inlet is supplied to the nozzle. The nozzle body is preferably provided in a generally cylindrical ejector housing.

The position of the outer surface of the nozzle may be controlled by use of an externally threaded portion on the nozzle body and a corresponding internally threaded portion on the ejector housing so that relative rotational movement of the nozzle body with respect to the ejector housing moves the nozzle.

Either the outer surface of the nozzle or the interior surface of the ejector throat is preferably convexly curved. This gives an accurate and sharp line of contact between the nozzle and the ejector throat which allows for the complete shut-off of the second fluid.

The interior surface of the nozzle body preferably tapers towards the nozzle, thereby reducing the cross-sectional area of the nozzle body towards the nozzle. This increases the velocity of the fluid as it passes towards the nozzle. This is particularly advantageous where the first fluid inlet is provided generally perpendicular to the axial direction of the nozzle body as the increase in velocity ensures a substantially smooth flow of the fluid through the nozzle despite the flow not being initially coaxial to the nozzle. By providing the inlet generally perpendicular to the axis of the nozzle body, the throttle can be axially provided in the body.

It is preferred that the throttle is a needle having a generally conical outer surface which is relatively movable in an axial direction with respect to the nozzle. As the needle moves axially with respect to the nozzle, a different diameter of the needle fills the central portion of the nozzle opening, thereby controlling the cross-sectional area of the opening. The needle may include an

externally threaded shank which corresponds to an internally threaded portion provided on the nozzle body, so that relative rotational movement of the needle with respect to the nozzle body causes relative axial movement between the nozzle and needle.

To give additional control of the cross-sectional area of the nozzle, an annular plug may be provided which fits in the opening of the nozzle to reduce the diameter of the opening.

Preferably, O-rings are provided between the nozzle body and the ejector body to give a sliding seal between the nozzle body and the ejector body.

Two examples of the present invention will now be described with reference to the accompanying drawings; in which:-

Figure 1 is a partly sectioned side elevation of the first example;
Figure 2 is a partly sectioned side elevation of the second example;
Figure 3 is a scrap underplan showing a slot inlet; and,
Figure 4 is a scrap underplan showing a slot inlet.

As shown in Figure 1, the ejector comprises a generally cylindrical ejector housing 1 that includes a nozzle body 2 and an ejector outlet 3.

The nozzle body 2 is a hollow body having a generally cylindrical outer surface, and a nozzle 4 at one end. The nozzle 4 has a frusto-conical outer nozzle surface. The interior surface of the nozzle body 2 tapers towards the nozzle end of the body. The nozzle body 2 includes an externally threaded portion (not shown), and the ejector housing 1 includes a corresponding internally threaded portion (not shown). By relative rotation of the ejector housing 1 and the nozzle body 2, the relative axial position of the nozzle 4 within the ejector housing 1 is adjustable.

The ejector body 1 includes a first fluid inlet 5. The side walls of the nozzle body 2 include holes 6 through which fluid entering into the ejector housing 1 through the first fluid inlet 5 enters the interior of the nozzle body 2. O-ring seals 7 are provided on the outer surface of the nozzle body 2 on either side of the holes 6 to provide a fluid tight sliding seal between the ejector housing 1 and the nozzle body 2.

A generally conical needle 8 is provided within the nozzle body 2, the tip of the needle 8 extending towards the nozzle 4. The needle 8 includes a generally cylindrical shank with an externally threaded portion (not shown) which corresponds to an internally threaded portion (not shown) on the interior surface of the nozzle body 2. Relative rotation of the needle 8 with respect to the nozzle body 2 causes relative axial movement of the needle 8 with respect to the nozzle 2, allowing the needle 8 to extend through and beyond the nozzle 2.

The nozzle 2 opens into an inlet 9 to an ejector throat in the ejector housing 1. The ejector housing 1 includes a second fluid inlet 10 which opens into the inlet 9 to the ejector throat. The ejector outlet 3 is provided downstream of the ejector throat. The inlet 9 has a generally conical interior surface. The inlet 9 leads into the ejector throat, which itself leads into the coaxial diffuser portion of the outlet 3. The diameter of the ejector throat is slightly greater than the diameter of the opening of the nozzle 4.

In use, a first fluid enters the first inlet 5 in the ejector housing 1 under pressure, and passes into the interior of the nozzle body through the holes 6 in the side wall. The fluid passes through the nozzle body 2, and is jetted through the nozzle 4 into the inlet 9 to the ejector throat. The second fluid inlet 10 is connected to a source of a second fluid. The jet of fluid from the nozzle 4 into the ejector throat causes a partial vacuum around the edge of the ejector throat. This partial vacuum draws the second fluid from the source and into the ejector throat. The jet of the first fluid together with the second fluid drawn into the ejector throat passes through the coaxial diffuser portion of the outlet 3 where the two fluids are mixed, and are ejected from the ejector.

The amount of the second fluid which is drawn into the ejector throat is determined by the gap between the interior surface of the inlet 9 to the ejector throat, and the outer surface of the nozzle 4. By rotation of the nozzle body 2 within the ejector housing 1, the nozzle 4 is moved relative to the ejector throat, thereby adjusting the spacing between the interior surface of the inlet 9 and the exterior surface of the nozzle 4. As the gap between the two substantially conical surfaces is controlled by a screw thread, the gap between the surfaces, and hence the control of the amount of the second fluid drawn into the ejector throat, is continuously variable. A stepwise adjustment may alternatively or additionally be provided. Such a stepwise adjustment may be provided by a releasable clamp or a ratchet mechanism. Where a stepwise adjustment is provided, it is advantageous to use the stepwise adjustment for course positioning of the nozzle with respect to the ejector throat, and fine adjustment by use of the screw thread. By substantially closing the gap between the nozzle 4 and the inlet 9 to the ejector throat, the supply of the second fluid can be substantially stopped. To improve the seal when the outer surface of the nozzle 4 closes onto the interior surface of the inlet 9, either the outer frusto-conical surface of the nozzle 4 or the interior conical surface of the inlet 9 are convexly curved to give an accurate line contact between the surfaces.

By adjusting the relative axial position of the needle 8 and the nozzle 4 by rotation of the needle 8 with respect to the nozzle body 2, the cross-sectional area of the opening of the nozzle 4 is adjustable. When the cross-sectional area of the nozzle 4 is reduced, the flow rate of the first fluid through the nozzle 4 is reduced, but the velocity of the jet of the first fluid through the nozzle 4 remains constant. Accordingly, the vacuum generated around the outer periphery of the ejector throat remains

substantially constant, and continues to draw the second fluid into the ejector outlet. Accordingly, adjustment of the relative position of the needle 8 and the nozzle 4 varies the volume of the first fluid jetting into the ejector outlet, but does not effect the amount of the second fluid drawn into the ejector outlet. Thus, the ejector allows complete control of the quantities of the first and second fluid ejected from the ejector.

The second example is generally similar to the first except for the formation of the second fluid inlet 10a and how it co-operates with the outer surface of nozzle 2. In the second example the outside of the nozzle 2 contacts the inner wall of the ejector housing 1 and so forms an effective seal with the inlet 10a when the nozzle is in its forwards position, to the left as shown in Figures 1 and 2. As the nozzle 2 is withdrawn the inlet 10a is gradually opened. The inlet 10a preferably has the form of a slot, as shown in Figure 3 or a triangular form as shown in Figure 4. More than one second fluid may be introduced if more than one inlet 10a is provided and these may be proportioned *inter se* by proportioning the areas of their inlets 10a.

An ejector according to the present invention has been produced having a 5cm water inlet supplied at a pressure of 525 kPa. The maximum nozzle opening is 3.14 cm^2 and adjustment of the needle was made to give a flow rate of between 9.30m^3/hour and 30.90m^3/hour. Throughout this range, and with a back pressure of 170 kPa, the vacuum produced by the jet was able to draw in a second fluid at a rate of around 10m^3/hour.

Claims

1. An ejector comprising:

a nozzle (2) having a generally conical outer surface (4);
a first fluid inlet (5) through which a first fluid is supplied to the nozzle (2) under pressure;
a throttle (8) for controlling the cross-sectional area of the outlet of the nozzle (2);
an ejector throat (9) having a generally conical inner surface which surrounds and is downstream of the generally conical outer surface (4) of the nozzle (2); and,
a second fluid inlet (10,10a) through which a second fluid is supplied in communication with the ejector throat (9), in which the first fluid is jetted through the nozzle (2) into the ejector throat (9) and draws the second fluid into the ejector throat (9) from where the first and second fluids are ejected.

2. An ejector according to claim 1, in which the position of the nozzle relative to the ejector throat is controllable to control of the flow rate of the second fluid.

3. An ejector according to claim 2, in which the position of the nozzle (2) is controlled by use of an externally threaded portion on the nozzle body (2) and a corresponding internally threaded portion on an ejector housing (1) so that relative rotational movement of the nozzle body (2) with respect to the ejector housing (1) moves the position of the nozzle.

4. An ejector according to any one of the preceding claims, in which the nozzle (2) is provided on a hollow nozzle body which includes apertures (6) in its side wall through which fluid from the first fluid inlet (5) is supplied to the nozzle (2).

5. An ejector according to any one of the preceding claims, in which the interior surface of the nozzle body (2) tapers thereby reducing the cross-sectional area of the nozzle body towards the nozzle.

6. An ejector according to any one of the preceding claims, in which the throttle is a needle (8) having a generally conical outer surface which is relatively movable in an axial direction with respect to the nozzle (2).

7. An ejector according to claim 6, in which the needle (6) includes an externally threaded shank which corresponds to an internally threaded portion provided on the nozzle body (2), so that relative rotational movement of the needle (8) with respect to the nozzle body (2) causes relative axial movement between the nozzle (2) and needle (8).

8. An ejector according to any one of the preceding claims, in which the outer surface of the nozzle (2) forms a seal with the second fluid inlet (10a) so that as the nozzle (2) is moved it opens and closes the inlet (10a).

9. An ejector according to claim 8, in which the inlet is shaped as a slot or as a triangular aperture to achieve the correct proportioning between the movement of the nozzle (2) and the flow rate of the second fluid through the inlet (10a).

10. An ejector according to any one of the preceding claim, in which the outer surface (4) of the nozzle (2) or the interior surface of the ejector throat (9) is convexly curved to give an accurate and sharp line of contact between the nozzle (2) and the ejector throat (9) which allows for the complete shut-off of the second fluid.

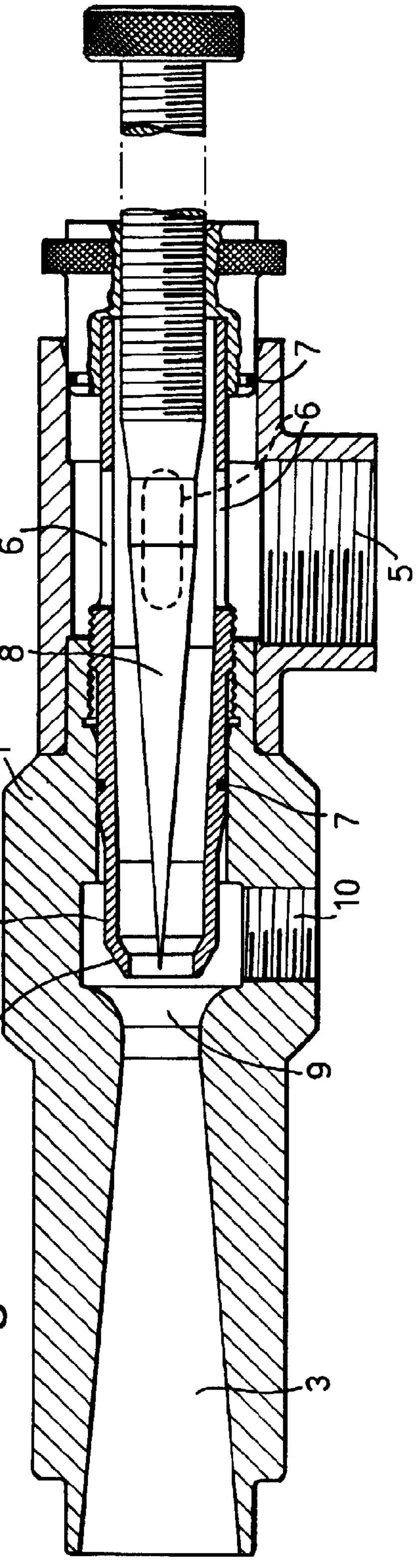

Fig.1.

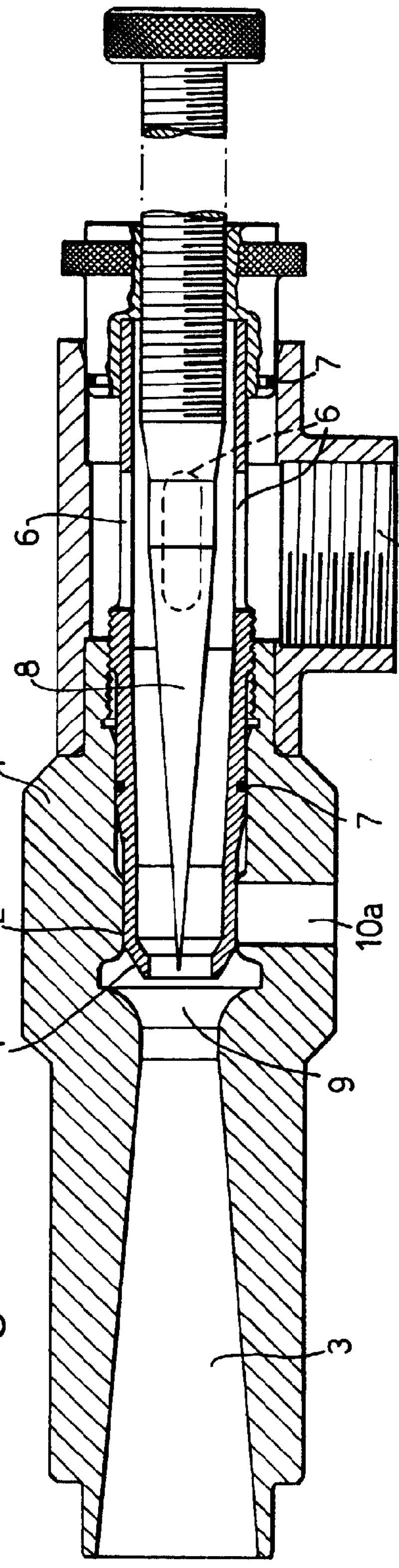

Fig.2.

Fig.3.

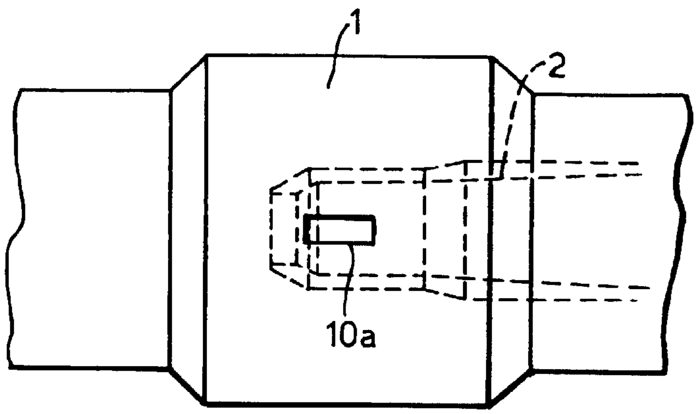

Fig.4.